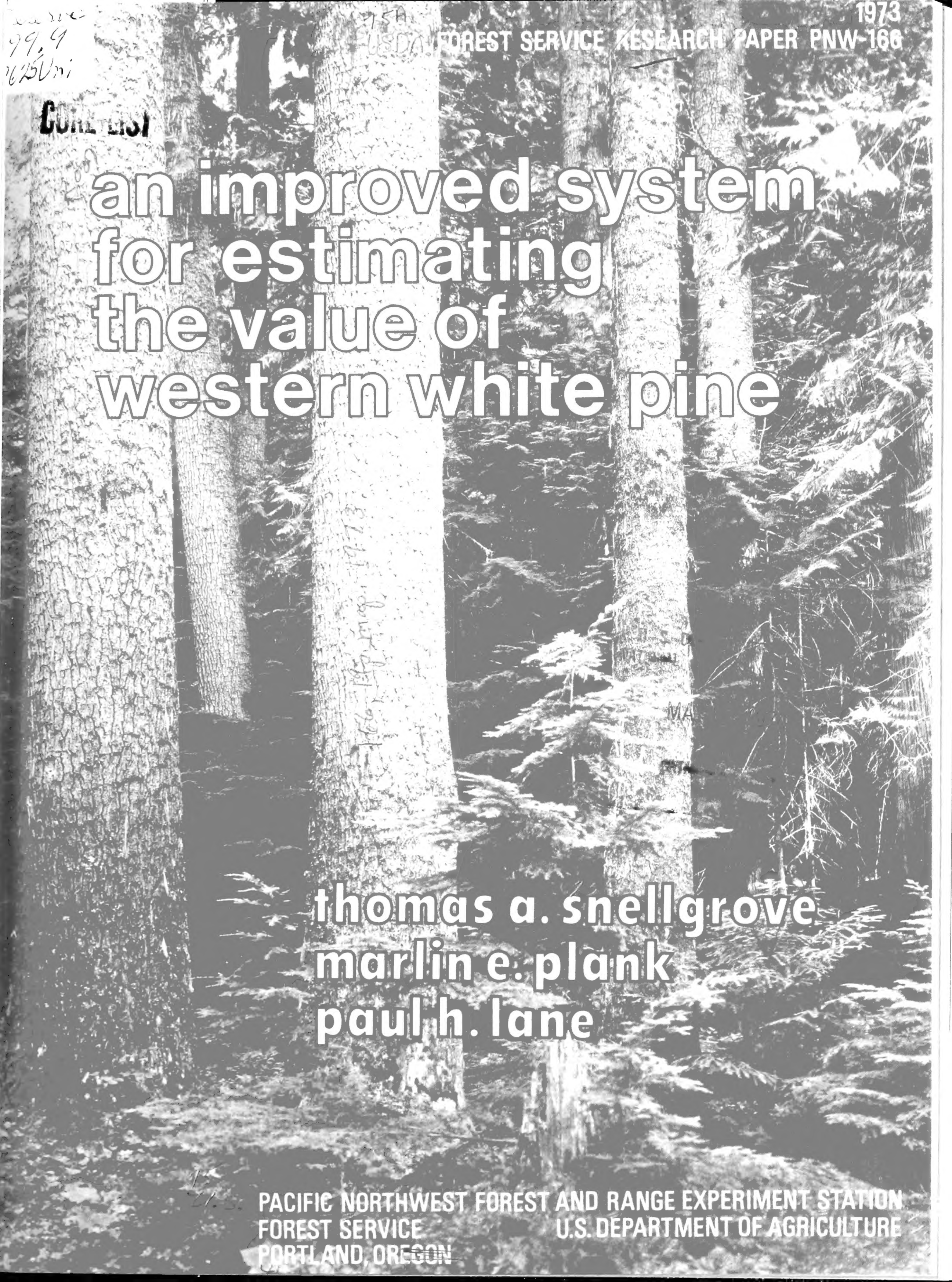

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an improved system for estimating the value of western white pine

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CONTENTS

ABSTRACT

This report describes an improved system for estimating the lumber selling value or volume of western white pine sawtimber.

Of 298 trees selected to represent the full range in size and quality of commercial sawtimber available in northern Idaho, 192 were used to develop a prediction model for estimating the value and lumber tally volume of individual western white pine trees. Of the remaining 106 trees, seven were culls and 99 were used to test the prediction equation.

The model developed contains six tree characteristics:

1. Tree diameter
2. Tree height
3. Height to the first live limb
4. The number of limb-free and defect-free faces in the butt 16-foot log
5. Diameter of the largest limb in the butt 16-foot log
6. Total tree defect percent.

The prediction equation, using those six characteristics, accounts for 94 percent of the variation in tree value and 95 percent of the variation in lumber tally volume as measured by the regression R^2 values.

A test of the system indicated that the prediction underestimated the value of all trees by 6.5 percent and underestimated the lumber tally volume by 2.7 percent.

The system is faster and more objective than log grading and has the additional advantage of eliminating grouping error by being a continuous predictor.

Keywords: Western white pine, tree value estimates, tree volume estimates, grading system.

INTRODUCTION

This paper, written primarily for timber appraisers, describes an improved system for estimating the lumber selling value or volume of individual tracts of western white pine (*Pinus monticola* Dougl.) sawtimber. It is similar to one described earlier by Lane, Plank, and Henley.[1]

Conventional systems for appraising the value of western white pine sawtimber incorporate volume and quality estimates of the resource. The estimate of quality has generally been in the form of discrete log grades. These log grades have often proven to be inadequate for a number of reasons:

1. *Application is slow and thus expensive.* The timber cruiser is required to scrutinize each 16-foot log throughout the merchantable stem.
2. *Application is difficult, subjective, and thus inconsistent.* To determine the grade for each 16-foot unit, the cruiser must categorize limbs as to size and whether they are live or dead. He must then determine the number in each category along with such information as the amount of clear area in these 16-foot units to determine the "grade." It is difficult for a cruiser to be consistent in application with such subjective inputs.
3. *Grouping error in estimating value is introduced.* When placing logs into discrete value classes (log grades), there will generally be a range of values within each class. Also, there is no distinct difference in value between the poorest logs of one grade and the best logs of the next lower grade.

The new system differs from the conventional log grading procedure in two principal ways: (1) It provides a selling value estimate for each cruise tree as a unit--therefore, it is more appropriately designated a tree grading system than a log grading system, and (2) the system does not group trees into restricted or discrete quality classes--it is a continuous system where the estimated value of each tree is in itself a "grade."

In comparison with a log grading system, this system has the advantage of being faster, and thus more economical; more objective and thus more consistent. It also eliminates grouping error by being a continuous predictor.

The following describes the development, performance, and application of the new system.

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[1] Paul H. Lane, Marlin E. Plank, and John W. Henley. A new and easier way to estimate the quality of inland Douglas-fir sawtimber. USDA For. Serv. Res. Pap. PNW-101, 9 p., illus. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg. 1970.

STUDY PROCEDURES

Sample

A sample of 298 trees was selected to represent the full range in diameter and quality of commercial western white pine sawtimber available in northern Idaho. The trees were from eight areas on the Kaniksu, St. Joe, and Coeur d'Alene National Forests as shown in figure 1. The eight areas were chosen to represent differences in tree size, stem quality, and site characteristics. Within each area, individual sample trees were selected on the basis of d. b. h. Some average characteristics of the sample trees by area are shown in table 1.

The study trees were felled and bucked into saw logs according to normal industry practice. The visible surface characteristics of each log were recorded immediately after the trees were felled.

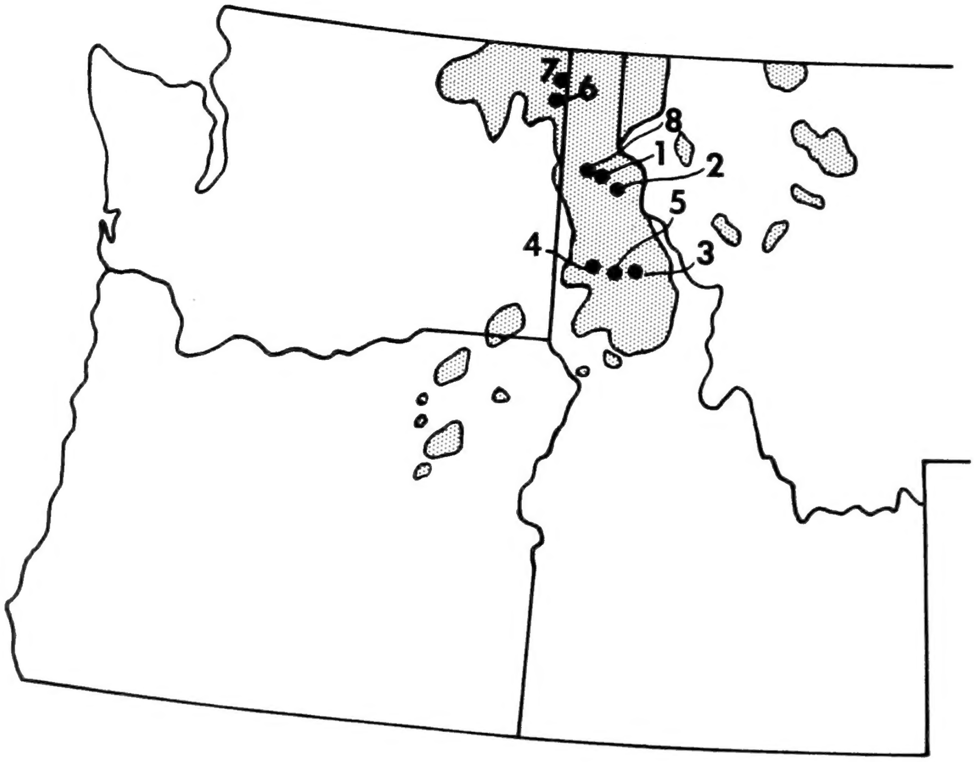

Figure 1.--*Range of western white pine in the "Inland Empire" and general locations of the eight areas from which study trees were cut.*

Table 1.--*Some average characteristics of study trees by sample area*

Characteristic	Sample area 1	2	3	4	5	6	7	8	Total or average
D.b.h. range (inches)	9.9-33.1	11.0-29.6	10.4-45.0	10.9-21.9	9.1-22.3	26.5-54.0	10.5-34.1	9.3-24.3	9.1-54.0
Average d.b.h. (inches)	14.4	23.5	20.9	17.1	13.3	38.4	21.9	15.2	19.2
Total height range (feet)	60-125	83-173	71-200	80-144	81-125	144-215	71-179	84-137	60-215
Average height (feet)	94	142	126	114	102	184	142	109	120
Defect range (percent)	0-66	0-51	0-91	0-19	0-29	10-98	0-56	0-39	0-98
Average defect (percent)	9.2	10.9	18.6	7.8	4.0	40.5	13.8	4.4	12.8
Age range (years)	49-134	107-211	60-170	58-111	53-88	237-336	123-290	58-77	49-336
Average age (years)	74	176	93	84	66	299	213	66	117
Number of trees	70	25	54	20	40	26	27	36	298

The sample trees were processed at what was considered a typical western white pine sawmill. The study logs were sawn under normal production conditions to obtain the highest value from each log. The usual white pine lumber items were produced, and the lumber tally values and volumes were based on kiln-dried, surfaced lumber tally according to general industry practice.

Developing the Prediction Model

Before data analysis, 99 of the 298 sample trees were drawn at random to test the prediction equations that would be developed. Of the remaining trees, 192 were used for model building and estimating the coefficients.[2]

The "stepwise regression" procedure and the "all possible regressions" procedure[3] were used to identify the tree characteristics that were most important in determining tree values and lumber tally volumes.

The general procedure used in building the model was to identify the factors that would affect the dependent variables of tree dollar value and lumber tally volume. These factors in the form of a general model are as follows:

tree value (dollars)
or = tree volume - tree defect + tree quality.
lumber tally volume

Each factor in the general model can be partially quantified by one or several individual tree characteristics (independent variables). A list of the independent variables that were examined can be found in appendix I. The stepwise regression procedure was used to identify those individual tree characteristics that best represented each factor in the general model. For example, the number of limb-free

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[2]Seven of the 199 trees selected for model building and estimating coefficients were omitted because they were cull trees, i.e., less than 25 percent of the gross volume of the tree was in sound wood. Consequently, the system is designed for sound trees only.

[3]Terminology taken from Norman Draper and H. Smith. Applied regression analysis. New York: John Wiley & Sons, Inc., 407 p., 1966.

faces on the butt log of the tree might best represent the factor tree quality. The independent variables that either had little or no effect on tree value or volume or were too difficult or impossible to quantify in cruising were omitted after screening. The remaining variables, along with alternative forms of the same variable, were screened by means of the all possible regressions procedure to choose the final variables for the model. The final variables selected for the model were those that were most practical for application in timber appraisals and those that statistically accounted for the most variation in lumber volume and value.

Six measurable characteristics survived as the most important and practical criteria for grading trees:

1. Tree diameter,
2. Tree height,
3. Height to the first live limb,
4. Diameter of the largest limb in the butt 16-foot log,
5. The number of limb-free and defect-free faces in the butt 16-foot log, and
6. Total tree defect (percent).

These six characteristics along with several transformations of the same characteristics were selected as the best independent variables for the model. These variables along with lumber yield information were used to develop the regression equations for predicting total lumber tally volume (board feet) and total value (dollars) on a tree basis. The equation for predicting tree value and/or volume is:

$$\begin{aligned}\text{tree value or tree volume} = {} & b_0 + b_1\, DEF\,(D^2H) + b_2\, D + b_3\, H + b_4\, HTFLL \\ & + b_5\, LRLB16\,(D^2H) + b_6\, NLFF16\,(D^2H) \\ & + b_7\, DEFSQR\,(D^2H) + b_8\, D^2 + b_9\,(H/D)^2 + b_{10} D^2 H\end{aligned}$$

where:

b_0 is Y intercept constant.

b_i i = 1-10 are the regression coefficients.

DEF is estimated percent defect of gross cruise volume.

DEFSQR is *DEF* squared.

D is tree diameter in inches at 4.5 feet above ground.

H is the total tree height in feet.

HTFLL is the height to the first limb with green needles on the tree.

*LRLB*16 is the diameter of the largest limb in inches in the butt 16-foot log.

*NLFF*16 is the number of limb-free and defect-free faces in the butt 16-foot log.

The equations developed account for about 94 percent of the variation in tree value and 95 percent of the variation of the tree lumber tally volume as measured by the regression R^2 values.

HOW THE SYSTEM PERFORMS

Of the 298 sample trees, 99 were selected at random to test the performance of the prediction equations. The six quality criteria measurements were recorded for each of the 99 trees. Predictions of the lumber selling value and volume were then calculated, using the procedures described in the next section of this paper.

Table 2 shows comparisons of estimated and actual values totaled for the 99 test trees. Plots of the estimated versus actual tree values and volumes of individual trees are shown in figures 2 and 3. As shown in figures 2 and 3, the value or volume of individual trees may not be estimated accurately by the equation; but there are approximately equal numbers of high and low estimates. Table 2 shows that there is little difference between the estimated and actual; i.e., a 6.5-percent difference for value and a 2.7-percent difference for volume.

Table 2.--*A comparison of actual and predicted lumber selling value and volume for 99 western white pine trees*

Unit	Estimated	Actual	Percent difference
Total value[1/] (dollars)	8,376.00	8,964.24	-6.5
Total lumber tally volume (board feet)	72,695.00	74,745.00	-2.7

1/ Value based on 1968 lumber prices developed for western white pine by U.S. Forest Service, Region 1.

HOW TO USE THE SYSTEM

Computer facilities for making regression analyses and solving equations are essential for efficient use of the system.

It is also necessary to have, in a form suitable for computer use, the tree characteristic data (the six grading criteria) and lumber grade yield data for each of the 192 trees from the mill study used to develop the system. A listing of the 192 cards containing the necessary information and the card format are illustrated in appendix II.

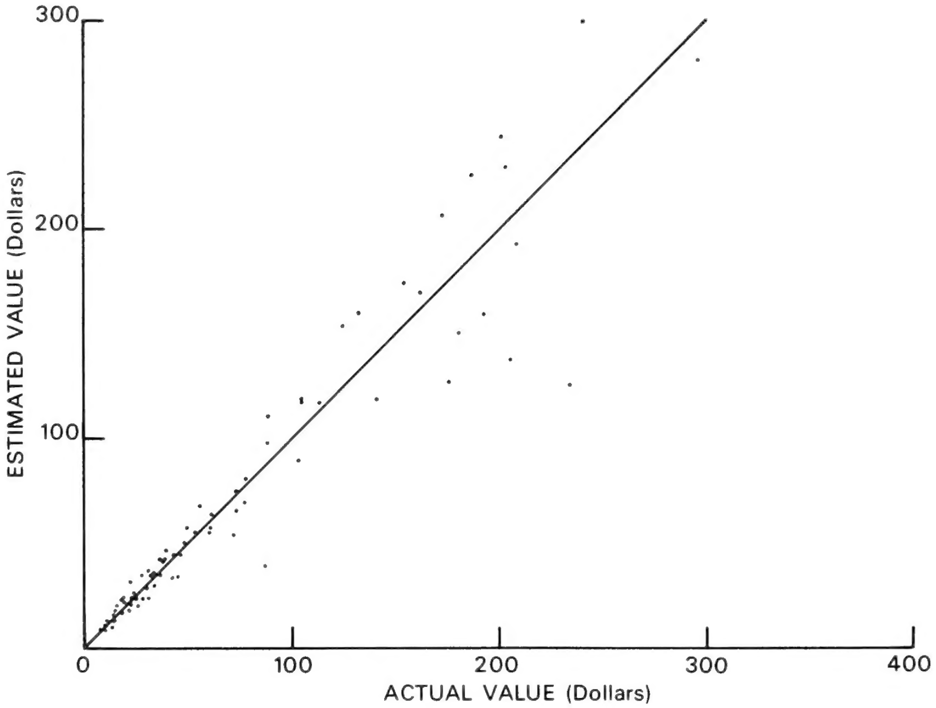

Figure 2.--*Plot of estimated over actual tree value.*

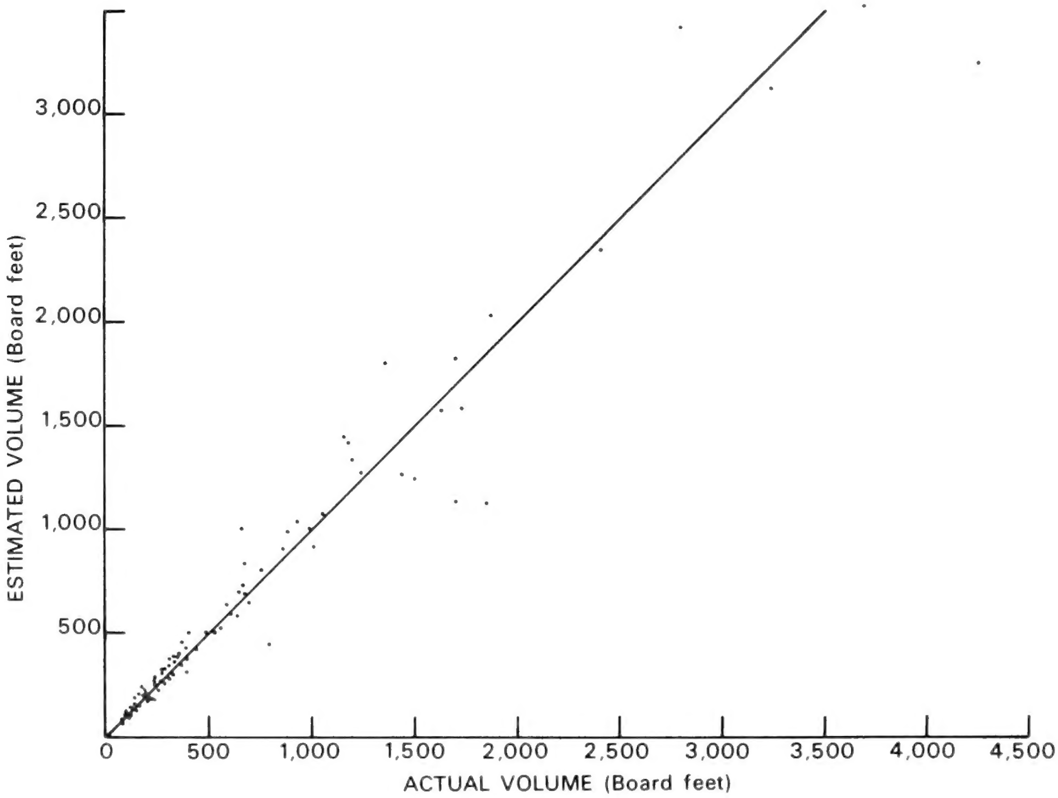

Figure 3.--*Plot of estimated over actual tree lumber tally volume.*

A step-by-step procedure for estimating the selling value of a group of trees or tract of timber is as follows:

1. Select sample trees.
2. Measure and record for each sample tree the six characteristics: (1) tree diameter, (2) tree height, (3) tree defect, (4) height to the first live limb, (5) size of the largest limb in the butt 16-foot log, and (6) the number of limb-free and defect-free tree faces on the butt 16-foot log. More complete information on how to measure and record these characteristics is shown in appendix III.
3. Assign desired lumber prices to each of the lumber grades (or combinations) recorded in the base study.
4. Using these assigned lumber prices, compute a dollar value for each of the 192 trees from the base study.
5. Use an appropriate multiple regression program to develop the value equation coefficients for the 192 trees. Use the assigned lumber prices (step 4) and the six tree characteristic variables and transformations as follows:

Dependent variable:

Total dollars/D^2H

Independent variables:

DEF

$DEFSQR$

$LRLB16$

$NLFF16$

D/D^2H

H/D^2H

D^2/D^2H

$(H/D)^2/D^2H$

$HTFLL/D^2H$

$1/D^2H$

6. Solve the value equation for the selected sample trees in step 1 using coefficients developed in step 5.

To estimate the lumber volume of a sample tree or group of trees, simply solve the following equation using the coefficients shown:

$$\begin{aligned}\text{Total lumber tally volume (bd. ft.)} = & -393 - (.00005126)(DEF)(D^2H) \\ & +(88.9538)(D) - (5.61835)(H) \\ & +(.40147)(HTFLL) - (.000131608)(LRLB16)(D^2H) \\ & -(.000323497)(NLFF16)(D^2H) \\ & -(.0000008985)(DEFSQR)(D^2H) \\ & +(2.27154)(H/D)^2 - (3.14853)(D^2) \\ & +(.0234706)(D^2H)\end{aligned}$$

CONCLUSIONS

Field application tests of the system indicate that the tree-valuation system reported has several advantages over valuation systems based on the discrete log grades currently being used.

It is faster to apply and thus more economical. Other than measuring total tree height and the height to the first live limb, the characteristics to be measured are confined to the butt 16-foot log. It is not necessary to look at each 16-foot segment as is the case with a discrete log grade system. It requires less experience and judgment by the timber cruiser; thus, training and checking of cruisers is easier. Selling price is computed easily and more directly than by procedures that involve adjusting yield by log overrun estimates. The user should remember that, as with any statistical procedure of this nature, the equations may not show the value of an *individual* tree accurately; they should be used to estimate the total value of a group of trees.

ACKNOWLEDGMENTS

The information presented in this report is the result of the cooperation of several organizations and a great many people. Loggers, truckers, scalers, foresters, and others made it possible to carry out this research.

Particular thanks are due the following organizations:

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Coeur d'Alene National Forest--for personnel for fieldwork and milling operations.

Western Wood Products Association--for providing a grading supervisor.

APPENDIX I. LIST OF INDEPENDENT VARIABLES

Defect Related

1. Defect percent
2. Defect percent squared

Presence or absence of:

3. Scars and/or seams
4. Basal scars and/or seams
5. Nonbasal scars and/or seams
6. All scars
7. Basal scars
8. Nonbasal scars
9. All seams
10. Basal seams
11. Nonbasal seams

Length of:

12. All scars and seams
13. Basal scars and seams
14. Nonbasal scars and seams
15. All scars
16. Basal scars
17. Nonbasal scars
18. All seams
19. Basal seams
20. Nonbasal seams

Presence or absence of:

21. Sucker limbs
22. Live sucker limbs
23. Dead sucker limbs
24. Bulges and/or bumps
25. Burls over 4 inches
26. Rotten knots
27. Conks
28. Broken top
29. Snow break
30. Blister rust cankers
31. Total number of burls
32. Total number of rotten knots on tree
33. Total number of rotten knots on butt 32-foot log
34. Total number of conks
35. Total number of knot clusters
36. Total diameter of burls
37. Total diameter of knot clusters
38. Sweep deviation
39. Crook deviation
40. Count of defects

Quality Related

41. Height to the first dead limb
42. Height to the first live limb
43. Size of the first dead limb
44. Size of the first live limb
45. Size of the largest limb (live or dead) on the butt 16-foot log
46. Size of the largest limb (live or dead) on the butt 32-foot log
47. Height to the start of the crown
48. Crown length
49. Crown length per height to the start of the crown
50. Height of clear bole allowing no defect
51. Height of clear bole allowing defect
52. Height of limb-free bole allowing no defect
53. Height of limb-free bole allowing defect
54. Total length of clear face in 4-foot minimum units in the butt 16-foot log
55. Total length of clear face in 4-foot minimum units in the butt 32-foot log
56. Total length of clear face in 8-foot minimum units in the butt 16-foot log
57. Total length of clear face in 8-foot minimum units in the butt 32-foot log
58. Total length of clear bole in 4-foot minimum units on the tree
59. Number of 4-foot clear panels on the tree
60. Number of 4-foot clear panels on the butt 16-foot log
61. Number of 4-foot clear panels on the butt 32-foot log
62. Number of 8-foot clear panels on the butt 16-foot log
63. Number of 8-foot clear panels on the butt 32-foot log
64. Number of 8-foot limb-free panels on the butt 16-foot log allowing defect
65. Number of 8-foot limb-free panels on the butt 16-foot log not allowing defect
66. Number of clear panels on the butt 16-foot log allowing defect
67. Number of clear panels on the butt 16-foot log not allowing defect
68. Number of limb-free faces on the butt 16-foot log allowing defect
69. Number of limb-free faces on the butt 16-foot log not allowing defect
70. Number of limb-free faces on the butt 32-foot log allowing defect
71. Number of limb-free faces on the butt 32-foot log not allowing defect
72. Number of 1-inch and less knots on the butt 16-foot log
73. Number of 2-inch and less knots on the butt 16-foot log
74. Number of 3-inch and less knots on the butt 16-foot log
75. Number of knots greater than 3 inches on the butt 16-foot log
76. Number of 1-inch and less knots on the butt 32-foot log
77. Number of 2-inch and less knots on the butt 32-foot log
78. Number of 3-inch and less knots on the butt 32-foot log
79. Number of knots greater than 3 inches on the butt 32-foot log

Volume Related

80. $DBH = D$
81. Total height = H
82. 16-foot form class
83. 32-foot form class
84. (D/H)
85. $(D/H)^2$
86. (H/D)
87. $(H/D)^2$
88 D^2
89. H^2
90. D^2H

Miscellaneous

91. Age
92. Amount of lean

APPENDIX II. TREE QUALITY CHARACTERISTICS AND LUMBER YIELD DATA

The tree quality characteristics and lumber yield data for each of the 192 western white pine trees from the base study are shown in the following list according to the card format shown below.

List of Characteristics

Columns	*Data*
1- 3	Tree Number
4- 6	Defect Percent
7- 9	DBH
10-12	Total Height
13-15	Height to First Live Limb
16	Largest Limb in Butt 16-foot Log
17	Number of Limb-free and Defect-free Faces in the Butt 16-foot Log
18-21	Volume B Select Lumber
22-25	Volume C Select Lumber
26-29	Volume D Select Lumber
30-33	Volume Molding
34-37	Volume 3 Clear
38-41	Volume 1 Shop
42-45	Volume 2 Shop
46-49	Volume 3 Shop
50-53	Volume 1 Common
54-57	Volume 2 Common
58-61	Volume 3 Common
62-65	Volume 4 Common
66-69	Volume 5 Common
70-73	Total Lumber Tally Volume

1–3	5–6	7–9	10–12	14–17	24–25	28–29	33	52–53	55–57	59–61	64–65	69	71–73
1	6	138	84	281	5				81	108			194
2		118	86	3211					43	75	22		140
4		109	88	321	5				48	66	11		130
6	17	133	99	401					136	74	20		230
7	4	139	87	321		18		5	140	90	31		284
9	11	150	103	4012		13	4		100	139	78		334
11		143	96	321		4			83	147	41		275
12	11	106	87	321		7		3	18	44	6	4	82
13		141	94	3211					87	164	31		282
14	13	123	90	4012				10	78	32	16		136
15		126	94	321		5		15	135	34	32		221
16	11	131	99	321					71	97	38		206
17	14	145	97	321					128	83	10		221
18	10	139	93	3211	2			5	112	91	7		217
20	5	132	94	401				7	125	53	32		217
22	3	170	97	401	3	7	5	15	121	210	18		379
24	11	157	102	321					64	187	66		317
25	10	147	90	321		13			64	130	39		246
26	5	144	98	321		5			109	119	38	3	274
28	21	120	94	321					28	63	24		115
31	4	165	94	321					136	182	76		394
33		151	91	361					54	197	62		313
35	8	112	83	361					63	38	8		109
37	7	119	89	321		5			56	82	8		151
41	9	162	103	321			5	8	115	158	100		386
42		169	86	321	2	8	5		216	135	25		391
43	6	170	90	321		27		7	162	165	42		403
45		152	104	361	7		3	8	151	77	68		321
46	15	219	100	301		59			102	306	165	11	643
47	8	150	85	3212	12				177	119			308
48	9	130	101	3211		3			106	84	28	4	225
50	15	146	103	401		30			57	153	17		268
51	9	141	92	3611		10		3	81	88	42		224
52	36	153	107	3211					19	124	26	4	173

2–3	5–6	7–9	10–12	13–17	19–21	23–25	27–29	31–33	35–37	39–41	43–45	52–53	55–57	59–61	63–65	67–69	70–72
53		102	73	361			4					8	62	56			96
54	5	121	90	4211			4						85	72	8		169
55	11	138	99	321									44	159	10		213
56	3	171	112	321									117	236	105	5	463
57	8	116	91	321									56	57	19	6	138
58		162	103	3611			5						116	175	72	4	372
59	3	178	96	361									191	215	60		466
60		111	77	401									43	45	16		104
62	40	104	81	4011									19	33	16		68
63		142	97	3211								5	145	117	5		272
65		120	92	12			4						83	63	31		181
66	33	187	101	321			5		7				75	221	47		355
67	4	152	100	321			2					3	89	195	36	5	330
69		142	102	321		4	3	5				5	53	162	21		253
70		135	105	321									120	90	7		217
71		243	155	5412	19	15	27	7	94	61	21	24	304	616	157	41	349
72	24	279	156	4621			44		27	69	10	32	216	683	387	81	476
73	4	270	166	6611		5	22	4		243	79		123	960	318	411	795
74	51	157	104	521			15						35	271	87	34	442
76	1	260	168	7013		36	150	24	73	47		36	448	564	195	271	600
77	4	296	166	52 3		16	104	41	134	145	114	46	163	990	173	41	930
78	44	110	83	241		7							7	34	17		65
79	10	224	152	9211	10	36	95	10		4		13	249	475	111	121	015
80	6	253	170	841		62	46	17	173	74	16		397	710	204	1	699
82		268	137	902 4	5	8	101	11		77	37	65	379	570	290	71	550
84	3	247	133	312	10	3	59	32	37	114	50		110	302	236	32	985
85		245	145	2012	13	54	72					47	523	618	24		351
86	15	253	147	6011		9	27	16	41	170	71	3	98	688	386	41	513
87	6	177	119	3212		4	21					16	267	96	11		415
89	42	238	128	3812		20	64			24	27		114	321	149	47	720
90	9	216	139	6011	3	13	74		10	13			58	608	153	14	946
91		166	109	148	12		11	5				13	78	182	47	12	360
93	4	289	165	480 4	16	141	171	39	114	29	49	30	203	737	326	371	892
95	20	198	123	20221		17	22	6				3	200	269	51	3	571

1–3	4–5	6–12	13–17	19–21	23–25	27–29	31–33	35–37	39–41	43–45	52–53	55–57	59–61	63–65	68–69	70–73
96		2200122	461	3						16		124	343	124		610
97		8199107	481			8					55	303	155	27	6	554
99	1	0202137	8012			35			11		16	368	394	10		834
102	2	6245149	7812				2				91	427	284	40		844
104	1	4223146	7612		39	24					7	285	392	33	12	792
106	7	5388200	23	6	47	133	74	74	58	80		4	167	338	69	1050
110	6	1397176	73 3	12	143	152	49	84	173	15	5	63	392	237	59	1384
111		3210122	6811	27	31	56			8		4	340	155	53	27	701
112		6160111	4012			23						173	194	32		422
115	2	6267156	3621		13	37					52	584	377	69	56	1188
116	2	4291130	401		10	35	22		7	23	14	355	547	232	56	1301
123		146 71	361			7						107	127	10		251
126		7234128	342			11	2		50			102	520	120	11	816
127	1	1162121	581								11	162	235	26		434
128		133103	441									63	138	23		224
129		3141126	3611			8					12	104	204	31	5	364
130	1	4117 97	441			11					7	100	47	12		177
131		3160101	622		3						7	102	237	31		380
132		178113	321		5	3						110	288	77	5	488
134		7182123	281			18		16				167	263	76		540
135		2251134	361	3	7	28	24				63	704	257	86	16	1188
142		201116	361				4		12	16		126	321	90	6	575
145	2	3149120	601			5						68	181	62		316
146		9166117	601			5						149	267	52		473
147		172113	361			14	5					184	191	58		452
148	1	4111806	551								11	13	65	47		136
149		5170123	361									110	259	98	7	474
150	1	3291144	4412	4	54	145	142	29	8	14	18	435	517	142	33	1541
151		5193106	3611			23					7	141	300	73	5	549
153		5171120	401		3							141	211	34		389
154		3219119	442		20	22		13	32	40	10	235	388	96	2	858
155		9170123	601		7	4	5	11				110	200	114	19	470
156	1	2109 80	361			7					11	27	33	20		98
157	1	2203134	641			9				22		85	401	226		743

158	23	168	118	1201						10	127	213	56	12	418
159	8	219	144	601			8				245	574	105	2	934
160	6	182	112	401			12				188	293	54		547
162	16	168	106	302						6	112	189	35	25	367
163	5	175	118	322			5		9	5	155	273	21		468
164		116	94	361				5			65	53	13		136
165	1	118	121	361		2	2			21	130	291	29		475
167		125	91	361							65	85	16		166
168	4	162	119	601			15			8	217	222	82		544
169	4	188	124	611							159	400	68		627
171		115	99	2511			9			7	69	57	11	3	156
173		157	110	441			16	3			60	256	13		348
174		139	118	3624	5		4			19	165	94	11		298
178	25	110	105	281							21	49	4	14	88
179		106	97	281							19	40	8	4	71
180		157	112	2413		12	8			28	210	83	34	3	378
182		114	100	241			5				57	80	12		154
183		146	94	1913			32				91	81			204
186	15	140	89	2413		3	7			3	3	131	11		158
188		134	95	2813							57	114	10		181
189		223	119	2414	8	19	6	5	16		45	511	90		700
195	17	91	95	3012	5						27	32			64
196	1	107	96	3612							16	78	16		110
197	4	145	113	481			8		10	19	143	131			311
199		118	103	3612							42	104	14		160
200		111	95	271							71	51	6		128
201		104	93	291							46	25	3		74
202		127	105	36							44	103	4	5	156
203		139	100	301				3		4	48	116	29		200
204	21	130	101	3212							48	102	8	2	160
205	14	122	106	32 3			3				74	58			140
208		94	83	122							11	30	13		54
209		130	100	20 4			10	7			82	93			192
210		121	103	361			2			4	58	88	16		168

1–3	5–12	13–17	19–21	22–25	26–29	31–33	34–37	38–41	43–45	52–53	55–57	58–61	62–65	67–73
216	63321181	84 4		52	73	9	11	50		4	365	347	88	121069
218	10507195	44 4	460	1023	884	628	323	334	115	62	253	1468	727	1536375
219	30540197	60 3	348	640	996	445	296	192	81	7	333	1007	447	1084934
224	50321178	64 2		30	143	9	23		23	41	201	449	383	501311
225	19429196	65 2	191	615	535	326	60	35	24	36	363	798	505	1173605
226	18450191	76 4	144	347	678	370	139	145	98	48	413	1423	721	4724998
228	14423179	40 4	122	4071	1072	414	32	92	21		184	1244	666	2444498
229	48421182	9212	61	239	309	102	70	76	79		134	872	369	922403
230	45368194	72	14	83	213	103	71	41	20		201	852	361	381997
232	33337180	96 1	36	90	193	101	28	82	22	42	263	1027	306	2282418
234	26358205	100 1	168	417	701	267	41	81	52		357	1067	462	2013814
235	30415215	124 3	69	302	533	242	234	274	81	29	188	888	777	1983815
239	27156125	4013			5		8				128	96	26	4 267
240	183110	4411		18	6					5	238	203	5	478
241	6160126	361		7	5					57	211	65	15	5 365
243	17114 98	361								10	94	43	3	150
246	2204148	4111		29	33	48	13				349	255	25	752
247	4180152	60 3	8	7	33					32	349	139	32	600
248	52243154	4412		72	70	8		16		22	205	447	86	10 936
250	5187130	6813	13	31	72					3	143	196	21	479
252	32341179	6011		14	56		60	90	36	16	477	897	341	3252312
253	3209145	4411			31					31	483	189	5	4 743
254	35316168	681		14	80	15	13	40		5	274	991	505	2362173
255	15240161	7611	9	7	83			8			491	652	165	1415
256	56228154	4412			10						102	307	161	83 663
257	4275155	54 4	13	140	154	7					462	346	70	1192
258	9238161	62 4	28	61	96	61					566	183	153	81156
260	7314172	62 4		15	102	52		43	40		251	1108	341	201972
262	115 95	44 3								3	61	23	34	121
263	105 71	3013									42	22	14	78
265	163114	201									169	169	13	2 353
266	2200126	362			5			8	25		217	318	75	648
267	9118 90	121									66	29	8	103
268	200103	192			3	5					252	195	45	2 502

270	10	243	137	322		17		5	50	58	6	23	155	550	184		1025
273		121	84	361									105	69	3		200
274	19	165	122	362									129	211	27	9	376
275	7	152	91	291								8	91	118	103		320
276	39	134	89	251									74	56	33		163
277		169	119	321		4		4				21	259	191	17		496
278		120	101	441									23	87	38		148
279		181	113	161				17				7	128	247	60		459
280	8	116	96	2011									110	54			164
281		142	108	271								24	78	140	54		296
283	3	165	115	521									176	242	32		450
284		99	94	281								4	12	38	16		70
286		157	124	321			3						40	186	151		380
287		110	103	461		2							43	69	17		131
288		102	92	251									62	37	8		107
290	3	157	108	361		3	4					42	187	114	58		408
292	2	187	127	321	4			5				12	275	188	57	12	553
294		93	98	401									11	46	12		69
295	4	209	142	321			3	5	13	9	10	66	317	380	60		863
297		209	135	302			4	6			18	69	300	252	112		761
299		137	100	321								13	154	57	20		244
300		125	109	441									78	116	16	5	215

APPENDIX III. INSTRUCTIONS FOR APPLYING THE SYSTEM

Instructions for measuring and recording the western white pine tree characteristics used in the equations are shown below.

1. *Tree diameter (D).*-- Measured and recorded to the nearest 0.1 inch at 4-1/2 feet above ground on the uphill side on the tree.

2. *Tree height (H).*-- Total tree height measured from the ground on the uphill side of the tree and recorded to the nearest foot. This height includes a dead top if one exists and the projected height if the tree has a broken top.

3. *Height to the first live limb (HTFLL).*-- Measured and recorded as the height (to the nearest foot) to the first branch[4] which has live needles.

4. *Largest limb in the butt 16-foot log (LRLB16).*-- Measured and recorded as the size of the largest limb (see footnote 4) in the butt 16-foot log.[5] Limb size is recorded inside bark but outside the limb collar. Limb size is rounded as follows:

0.25 - 1.0 = 1 inch
1.1 - 2.0 = 2 inches
2.1 - 3.0 = 3 inches
etc.

5. *Number of limb-free and defect-free faces in the butt 16-foot log (NLFF16).*-- A face is one-fourth the circumference of the tree for the full 16-foot length of the butt 16-foot log (see footnote 5). Any limb or limb stub other than epicormic limbs removes a face. Any scalable defect removes the face in which the defect occurs.[6] All size knot indicators are allowed. The variable is coded as 0-4 faces.

6. *Scalable defect (DEF).*--Expressed as a percent of the gross cruise volume. The estimate includes deductions made from the gross cruise volume for visible abnormalities such as crook, conks, cankers, burls, and bumps. It also includes the estimated volume loss from unknown sources such as logging breakage and hidden or internal defects such as rot or pitch rings.

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[4]Epicormic branches are not recorded.

[5]Butt 16-foot log defined as the first 16.5 feet of the tree above normal stump height.

[6]If crook and/or sweep occurs in the butt 16-foot log, one face is removed.

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